GEAR GRINDING SERVICE LEVELS TAKEN TO NEW HEIGHTS

Automatic machine component monitoring, or ACD, can be used by applying artificial intelligence (AI) to predict and avoid negative wear impacts.

By DR. CHRISTIAN DIETZ and WALTER GRAF

Continuous generating gear grinding has established itself as the preferred method of hard-finishing automotive gears. The machine tools – the gear grinding machines – have reached an elevated level of maturity, leaving little room for improvement on the mechanical side. However, recent developments in process and component monitoring have added a new dimension to the performance of these gear-grinding machines. Additionally, machine components are subject to wear over time. The critical questions regarding wear are when it may affect gear quality and cause NVH issues.

To answer these questions, this article focuses on automatic machine component monitoring, called ACD, and how this is used by applying artificial intelligence (AI) to predict and avoid negative wear impacts. In the context of Reishauer gear grinders, component monitoring refers to all machine axes and their bearings used in the grinding process to achieve the required quality of the tooth flanks.

ARGUS

For this purpose, Reishauer has developed a process and component monitoring system – ARGUS –based on artificial intelligence (AI). Several prerequisites must be met for artificial intelligence to be effectively used in the first place. First of all, a large amount of curated data is needed, based on which it becomes possible to derive physical regularities on which to design algorithms. In this context, there is also a need for experts and professionals from the gearing industry who can program the algorithms required for AI. In a nutshell: AI has to be hard-won.

"Intelligence" in AI is based on lengthy processes of sending reviewed and curated data sets through neural networks. Subsequently, the data output results must be checked, revised, and sent backward through the neural network. In this manner, the AI system continuously learns, constantly corrects itself, and adjusts the algorithms accordingly. This process is also called deep learning. So, what can artificial intelligence do much better than human intelligence? AI can find the proverbial needle in a haystack at lightning speed. AI is based on pattern recognition, uncovering unusual correlations in enormous amounts of data that would usually escape human intelligence. AI is, first and foremost, a decision-making technology. In the context of component monitoring, speed and accuracy of decision-making are imperative, and AI is lightning fast.

CLOUD STRUCTURE

Automated component monitoring requires a cloud structure for data storage to cope with the large volumes of data continuously generated by countless grinding machines around the clock.

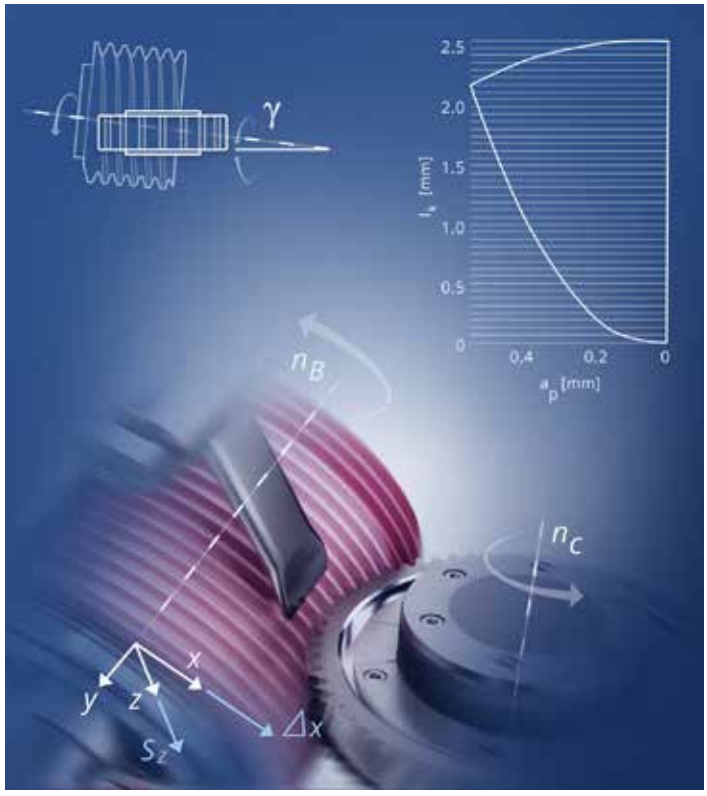

Figure 1: Continuous generating gear grinding.

Reishauer continuously increases its knowledge base. Today, Reishauer has about 20 million grinding cycles and all their data points, with a monthly increase of 500,000 to 800,000 cycles. At this juncture, it is important to mention this data is anonymous and not linked to any specific customer. With complete parameter data, 20 million grinding operations are a huge enough data pool to apply data science and AI for pattern recognition. These data sets give enormous insight into the processes with different grinding parameters. For example, this data pool allows Reishauer insights

regarding the optimal performance of individual machine axes.

ANONYMOUS DATA SETS

The individual data sets remain anonymous, which is important for customers and Reishauer. However, all the general insights Reishauer gains by analyzing the data can steadily be fed into ARGUS updates. In this manner, all subscribed customers gain a deeper knowledge of their generating gear grinding processes.

Furthermore, it requires overarching machine algorithms that can evaluate the anonymized data about the states of the machine components in real time with AI. The grinding machine runs autonomous cyclic tests that reflect the components' conditions. Since the grinding machines generate enormous quantities of signals, the signal quantity is only useful if it can be interpreted. To this end, in the past, it was necessary to bring in a highly skilled person who knew how to interpret and analyze signal changes -- especially in real time -- because it is paramount to interpret the data before any critical process condition can occur. No matter how experienced, this person cannot interpret the multiple problems in the volumes of data generated today. Furthermore, this skilled service engineer had to come to the customer first to evaluate the situation. Now, ARGUS allows the data analysis from Reishauer's homebase.

The ACD does not expect errors but is constantly evaluating and thus uncovering tendencies in the deviations. It is only on the basis of analyzing these tendencies that preventive maintenance becomes possible. Due to the large amount of data, the ACD finds even the smallest errors or deviations. The detected errors can then be traced back to a bearing of a machine axis, to name one example. If errors are detected, and a Reishauer service engineer is called, the engineer can arrive prepared with the necessary spare parts and an action plan. This level of preparedness is only possible through the troubleshooting capabilities of ARGUS and results in minimal downtime and reduced service costs. Furthermore, after replacing parts, ARGUS will unequivocally show whether the service was successful. All of this raises the service level Reishauer offers its customers to new heights.

Only enormous amounts of data, available anonymized in a cloud, make it possible to train the corresponding algorithms. It is important to mention the legal regulations concerning data protection must be strictly observed. The machine can be checked as often as required without needing personnel, without interrupting the production cycle, enabling preventive maintenance, and saving user costs. Machine downtimes are minimal, and service interventions can now be planned.

Over time, the precision of the algorithms continues to improve as the knowledge gained leads to further developments and refinements. In addition, since sensor technology is constantly evolving and always integrated into the ARGUS system, this also continuously upgrades the analyses and the algorithms. Whereas failure analyses took a huge amount of time, with the help of ARGUS, the Reishauer experts can perform a failure analysis very quickly. For example, the specialists can predict a potential NVH problem (disturbing transmission noise) from the signals, preventing faulty parts from being installed in the finished transmission. Previously, such problems required an expensive and time-consuming trip to the user's site.

INDEXING 'GOOD' AND 'BAD'

In addition to preventive maintenance, ACD's great strength is to index between "good" and "bad." Thus, not only are trends visualized, but signal patterns are distinguished between "good" and "bad." This differentiation helps the user save costs by minimizing downtime and avoiding major damage to the machine.

Component monitoring is only one aspect of ARGUS. The other important dimension is process monitoring to move ever closer to the desire for zero-defect production. All parts that come off the grinder are individually evaluated and automatically removed if found outside specifications. The latest version of the Reishauer machine also implements closed-loop technology in collaboration with the measuring machine builder Mahr. This topic will be taken up in future articles. Process and component monitoring can avoid NVH issues, improve productivity, eliminate rejects, and reduce costs.

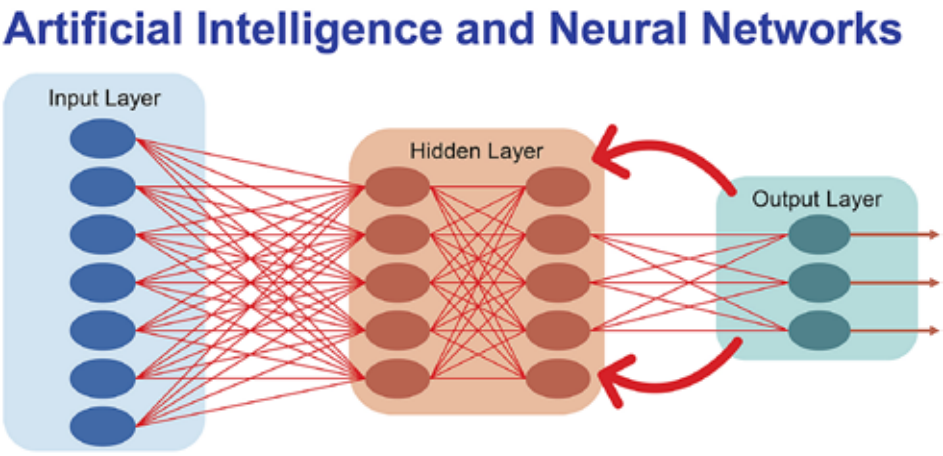

Figure 2: Neural network.

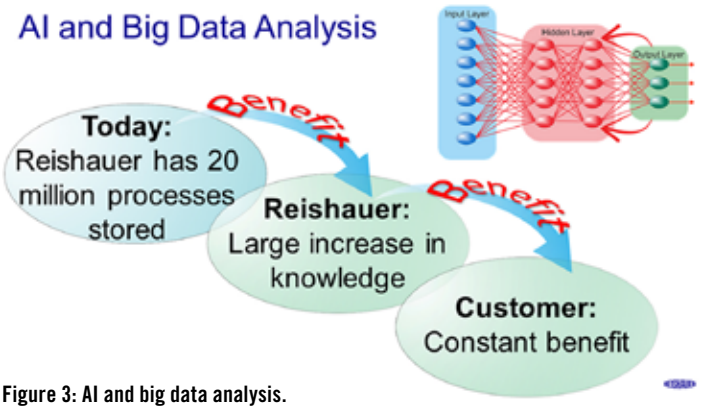

Figure 3: AI and big data analysis.

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